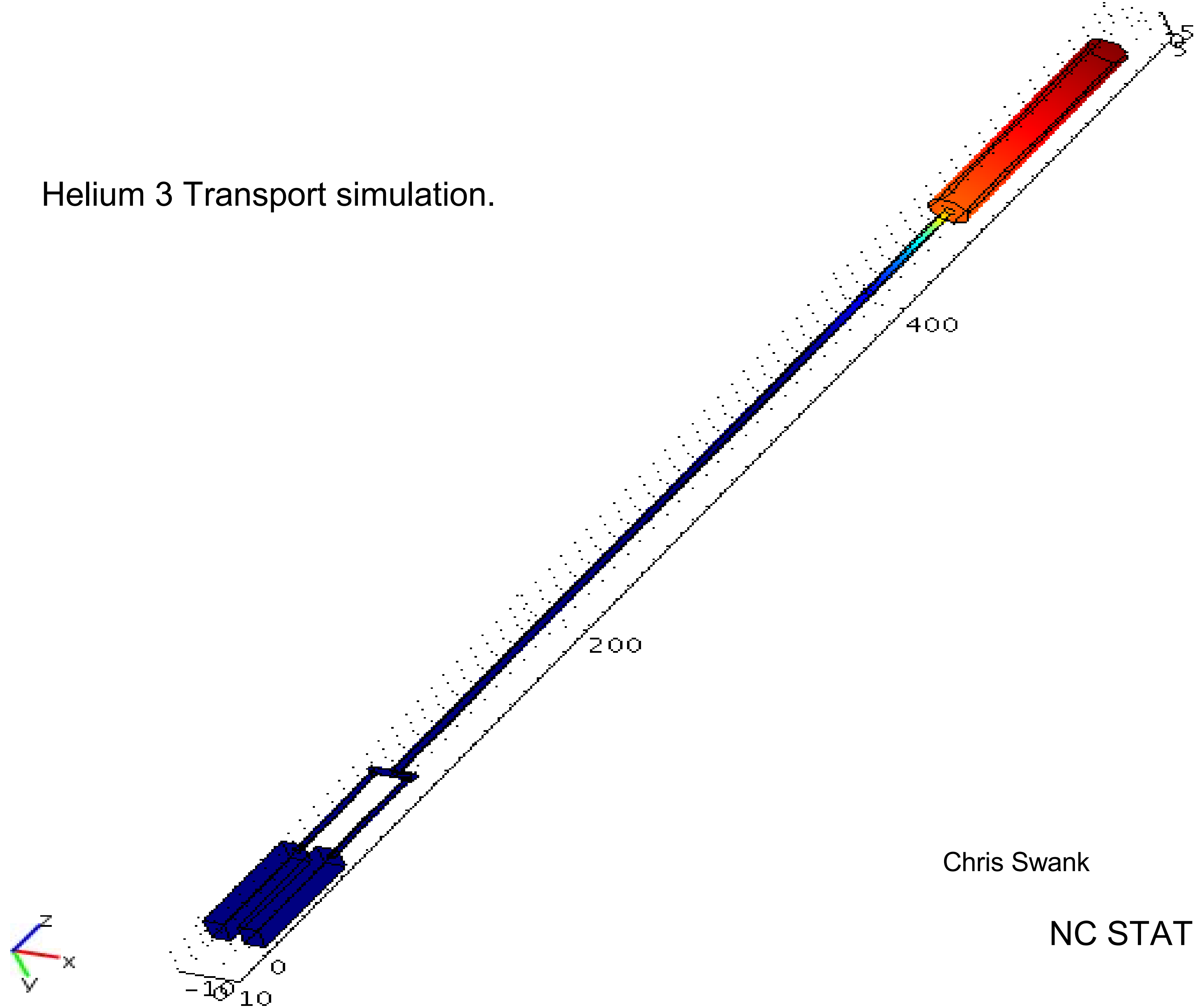
Helium 3 Transport simulation.



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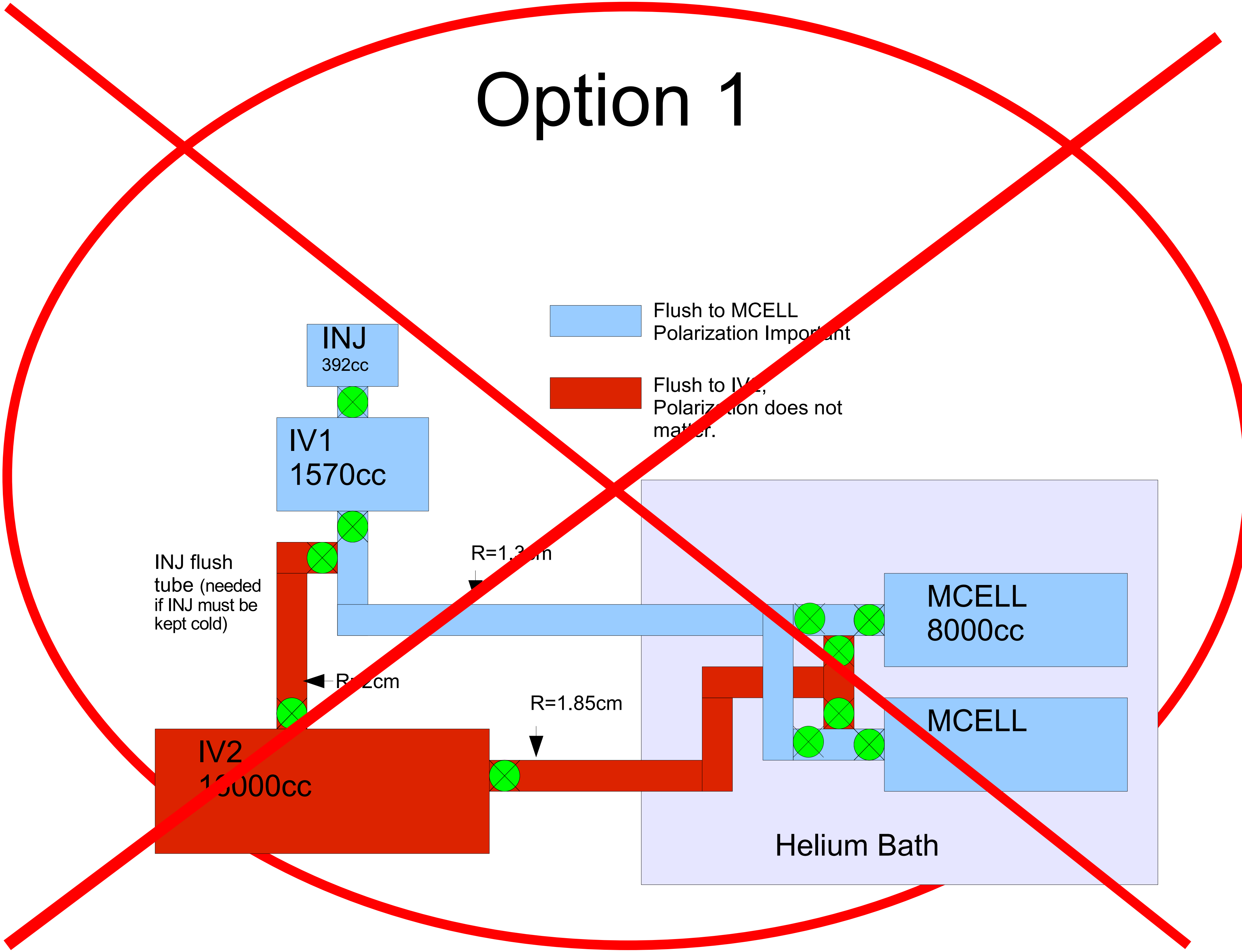
Overview

i. The Measurement Cell (MCELL) must be flushed to .3% of its value during measurements.

ii. The Polarization in the MCELL must be at least 99%. In other words, minimize time spent in pipes, minimize surface area to volume ratio in the pipes, while considering heat budget.

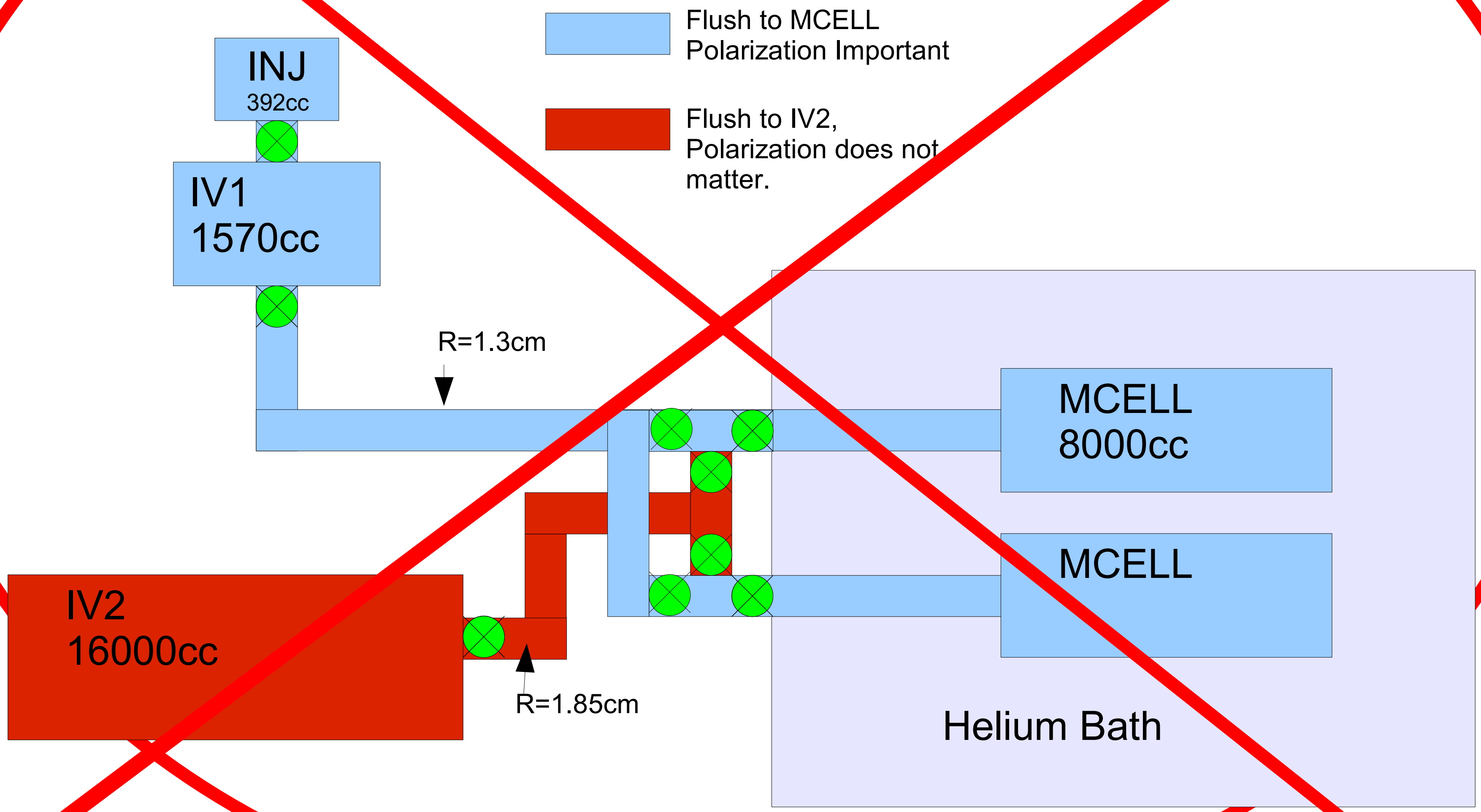
Option 1



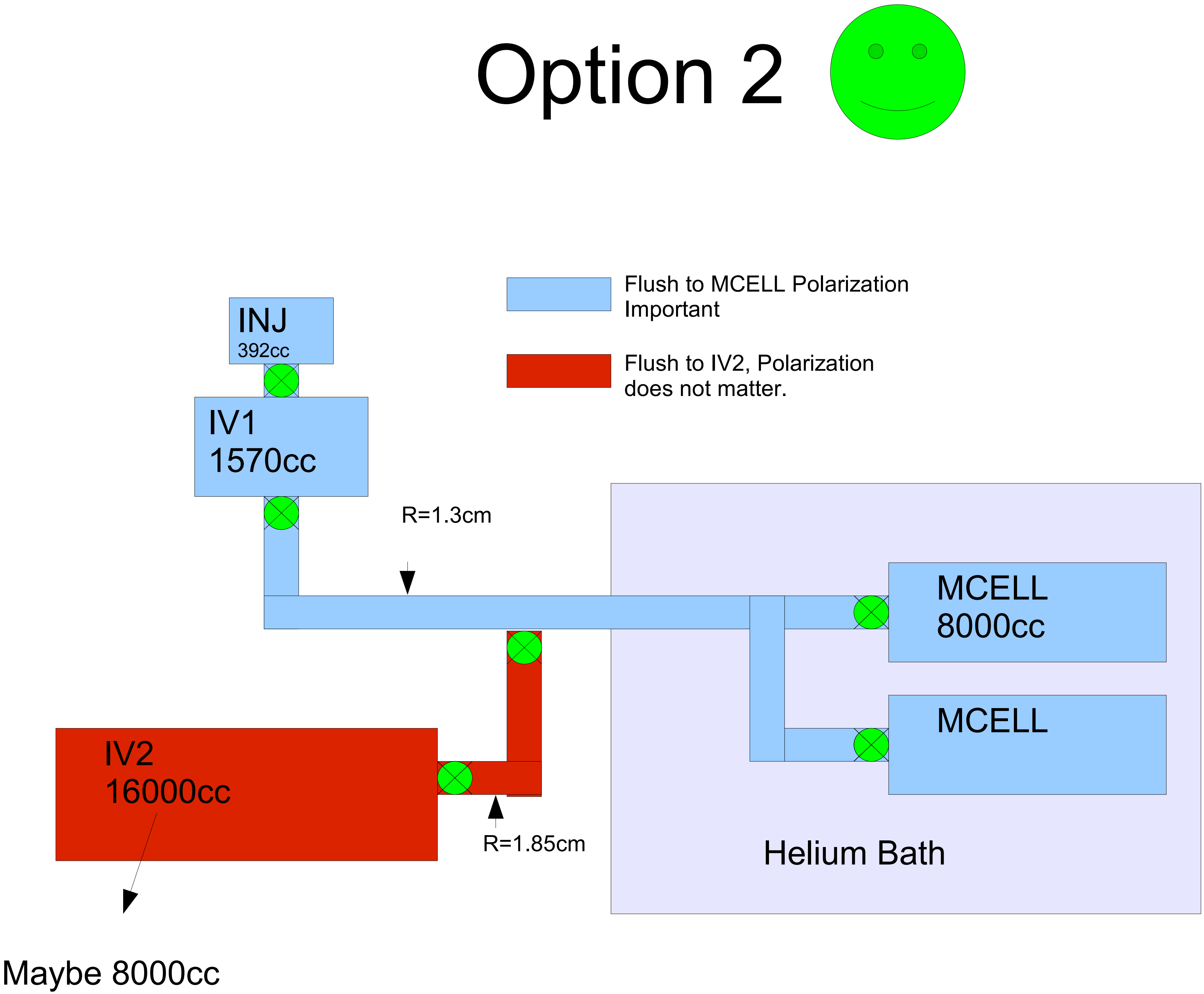
Flush to MCELL
Flush to
INJ
392cc
IV1
1570cc
INJ flush tube (needed if INJ must be kept cold)
R=1.85cm
MCELL
8000cc
MCELL
IV2
Helium Bath

Option 1b

Cannot be simulated in 2-D axial symmetry.



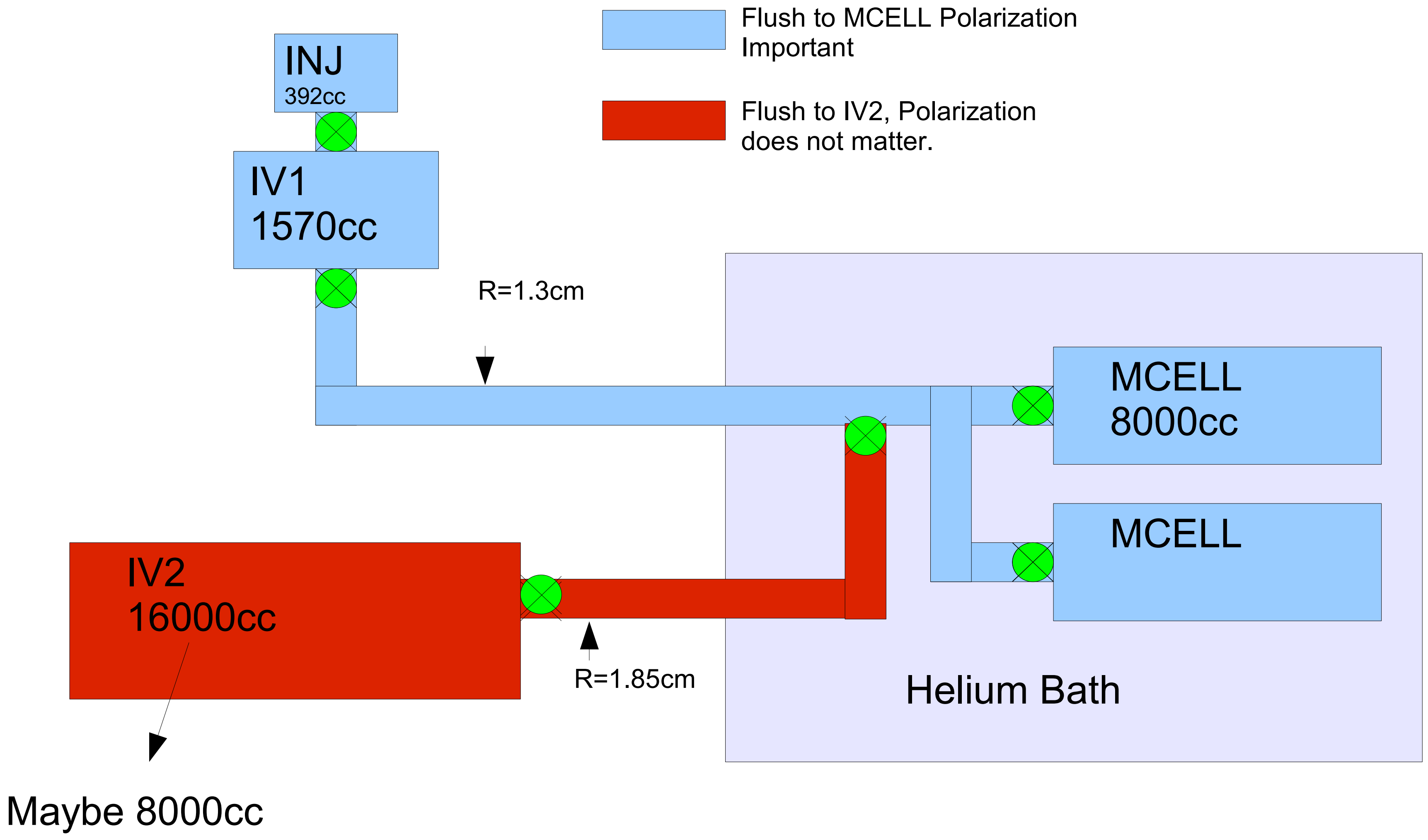
Option 2



Flush to MCELL Polarization Important
Flush to IV2, Polarization does not matter.
INJ
392cc
IV1
1570cc
R=1.3cm
MCELL
8000cc
MCELL
IV2
16000cc
R=1.85cm
Helium Bath
Maybe 8000cc

Option 2b (not to be?)

- Faster Flush with less heat flux from MCELL to IV2



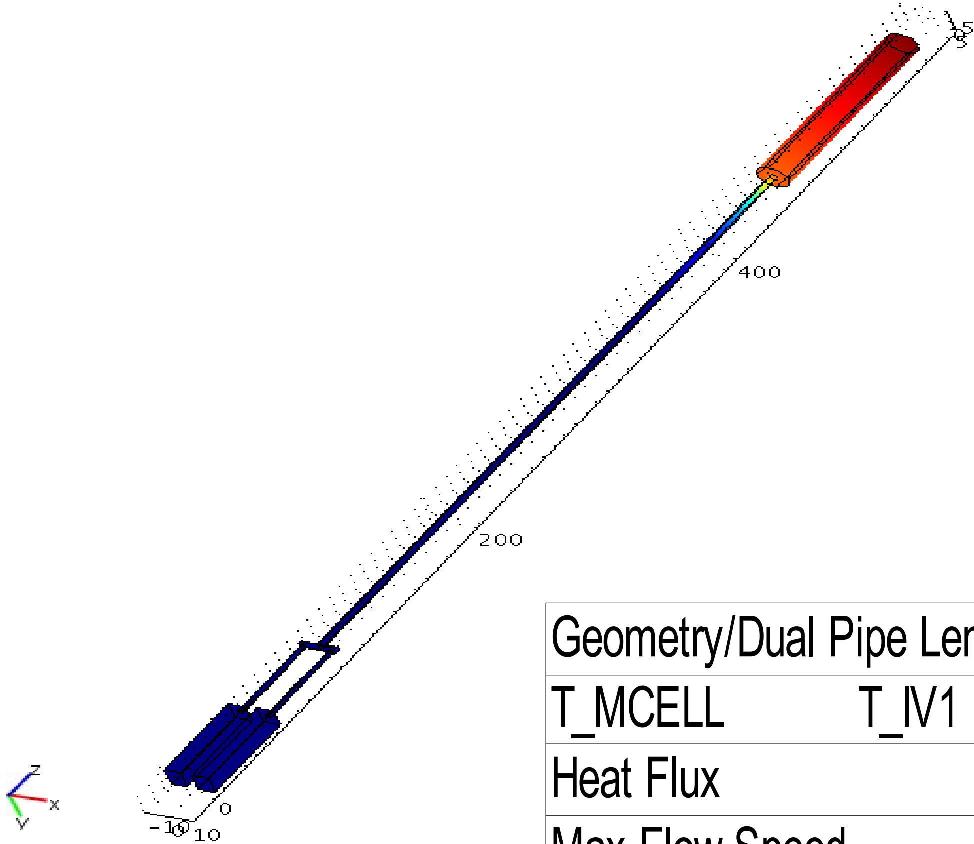
Whats the difference? The emptying of the Measurement Cells

- The flush from the Measurement Cells into IV2 is more efficient in Option 1 than Option 2.
- Option 2 is less complicated.

Parameter	Option1 7mW	Option2 8mW	Option 1b 7.7mW
Total Pipe Length, first part, second part [cm]	450, 25, 425	450, 110, 340	450, 100, 350
First Pipe Radius, Second Pipe Radius [cm]	1.3, 1.85	1.3 1.85	1.3, 1.85
Vmax [cm/sec]	62	63	44
Temp [K]	MCELL: 0.45 IV2: 0.432	MCELL 0.45 IV2: 0.432	.45 .420
time for c < 0.3% [sec] (MCELL and 25 cm of pipe)	294	285	249

3D simulation
gives better result

3D simulation of MCELL to IV2



Option 1b

Geometry/Dual Pipe Length	50cm	100cm
T_MCELL T_IV1	.45 .423	.45 .420
Heat Flux	7.6 mW	7.7mW
Max Flow Speed	40 cm/sec	44 cm/sec
Time for c<.3% in MCELL & Dual Pipe	237 seconds	249 seconds

Flush from IV1 to MCELL

The 2D model MCELL has less surface area per volume than the 3D model.

This led to .1% decrease in final Polarization. Still within the acceptable range.

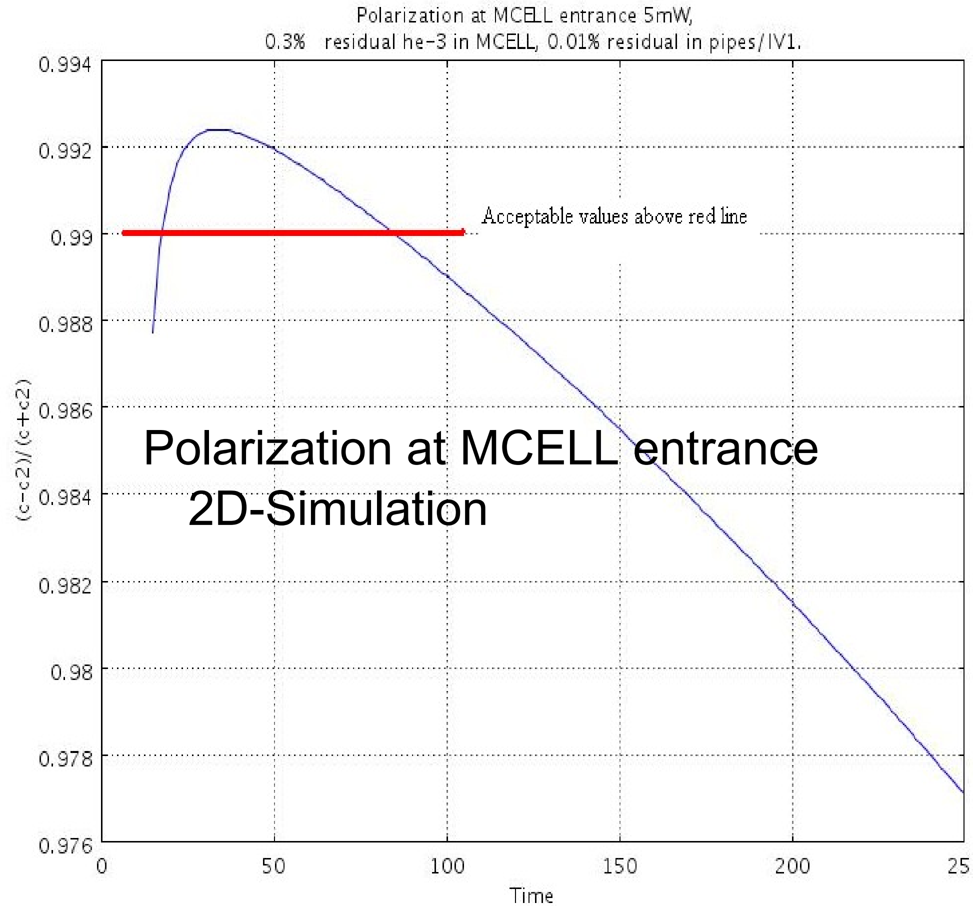
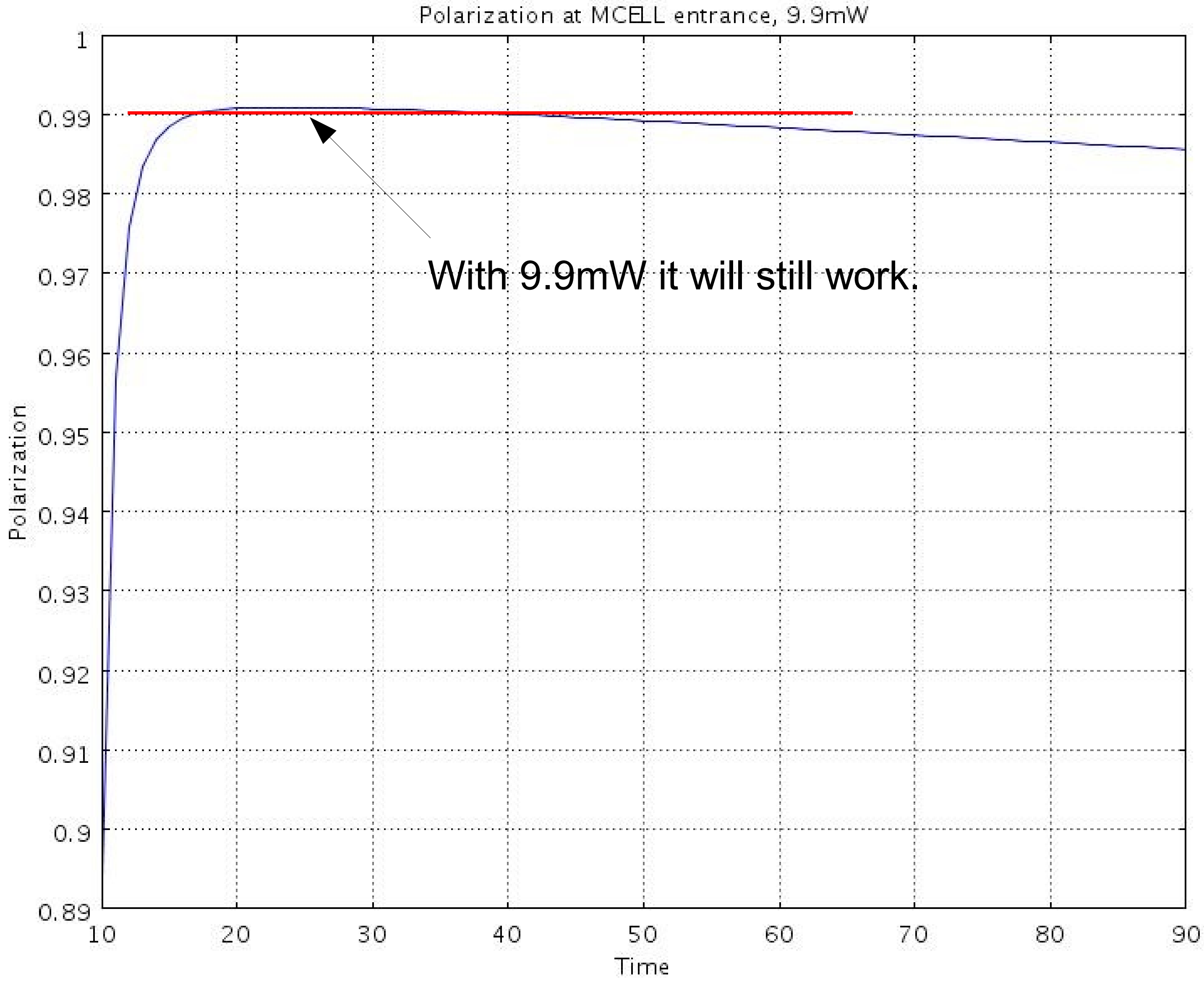


Table: IV1 to MCELL 2D and 3D models

Parameter	2D model	3D model
Pipe Length [cm]	300	200, 100 Dual
Pipe Radius [cm]	1.3	1.3
Vmax [cm/sec]	44	39
Temp [K]	cell 0.45 IV1: 0.477	cell 0.45 IV1 0.47
Fraction of He3 in MCELL at max polarization	0.76 at 35 seconds	0.79 at 27 seconds
Max Polarization of He3 in MCELL	99.2%	99.1%
Fraction of He3 in MCELL after 75 sec	0.973	0.98
Polarization of He3 in MCELL after 75 sec	99.06%	98.84%

By the way, 4.5 not 3.



4.5m Distance

Assumptions:

- Probability of depolarization per bounce is 1e-7.
- MCELL is magically kept at 450mK or 9.9mW of heat can be extracted from MCELL without a terrible Temp. gradient.
- last 1.7 meters of tube are 'leaky'

Parameter	3D, 450 cm from IV1 to Mcell, 9.9mW flux
Pipe Length [cm]	450
Pipe Radius [cm]	1.3
Vmax [cm/sec]	61
Temp [K]	cell 0.45 IV1: 0.52
Percent of He3 in MCELL at max polarization	60% at 24 seconds
Max Polarization of He3 in MCELL	99.08%

Conclusion.

- 3D simulations do not change the results drastically.
- 4.5m distance from IV1 to MCELL seems possible, yet borderline.

Thank you!